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Analysis of the Report of Dr. Kevin Neels
On Behalf of United Parcel Service

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Introduction

The Postal Service requested that I review the report prepared by Dr. Kevin Neels on behalf of United Parcel Service, to see if it contains any suggestions useful for improving the Postal Service's proposed update of the model that attributes city carrier street time costs to products. This request is a logical extension of the collaborative process that the Postal Service has followed in pursuing its update of the city carrier street time costing model. Over the last several years, the Postal Service has publically presented, and solicited feedback on, the essential issues of the update, like the use of ongoing data systems, the need for selective field studies, methodologies and sample sizes for collecting data, and determination of the econometric models to be estimated. This ongoing process allowed a consensus to be achieved on a number of key methodological issues before scarce resources were expended on the necessary research.[1]

In his report, Dr. Neels reviews and criticizes the Postal Service regular delivery time equation, and proposes some alternative approaches. As demonstrated below, my review of Dr. Neels' criticisms shows them to be without merit. They appear to be based upon either a lack of familiarity with city carrier street time operations or a lack of experience with current econometric practice.

I also reviewed Dr. Neels' proposed alternative approaches to estimating the regular delivery time equation and found that in only one instance did a proposed alternative merit further consideration. That issue, first raised by the Postal Service in 2012, is whether the regular delivery equation should include aggregate or disaggregate

[1] See, for example, PRC Order No. 1626, Docket No. RM2011-3 (January 18, 2013).

volume variables.[2] For some reason, Dr. Neels did not pursue the complete set of tests he proposed to investigate this issue. Consequently, he drew an erroneous inference about the appropriate level of aggregation. Performing the complete set of tests allowed me to pursue the appropriate aggregation, and to develop a regular delivery equation utilizing that level of aggregation. The results of estimating that model are presented below.

Dr. Neels' report raised five issues of substance. Each of those issues is presented and analyzed below. Before addressing them however, it is relevant to point out examples of erroneous speculations made by Dr. Neels, which are apparently based upon unfamiliarity with city carrier processes and procedures. These types of errors undermine the credibility of Dr. Neels' report.

First, Dr. Neels confuses cased packages with in-receptacle packages, and thus makes a mistaken speculation about the Postal Service's data collection procedures. Dr. Neels first quotes the Postal Service's Report on City Carrier Street Time, indicating that there are some pieces, cased packages, which are classified as packages in the DMM, but are handled as flats by carriers.[3] He then argues that the package and accountable study instructions "appear to instruct carriers to keep in-receptacle parcels separate from the regular stream of mail with which they are normally grouped."[4]

Dr. Neels speculates that there is a problem with the Postal Service data collection procedures because they required carriers to deviate from their normal

[2] See, "Scoping Study Report of the United States Postal Service," Docket No. RM2011-3 (May 30, 2012), at 47.

[3] See, "Report of Kevin Neels on Behalf of United Parcel Service," Docket No. RM2015-7, at 31

[4] Id.

procedures: he asserts the procedures require carriers to keep packages separate when they should not. This speculation is in error. The study did not require carriers to deviate from their normal procedures, as in-receptacle packages are indeed kept separate from letters and flats until the moment of delivery. This is true for both walking routes and driving routes.

Dr. Neels apparently overlooks the fact that city carriers deliver three types of packages: cased packages, in-receptacle packages, and deviation packages. Cased packages are handled as flats, and delivered together with other cased letters and flats as explained in the Postal Service report. In-receptacle packages are kept separate from letters and flats, and are delivered after the letters and flats are put in the receptacle. Deviation packages are also kept separate from letters and flats, and require a carrier deviation for delivery.

Dr. Neels also speculates that data collected in the package and accountable field study is subject to a "Hawthorne effect," in which observation of a carrier's activities causes his or her productivity to rise because "their performance is being measured."[5] He thus argues for using "routinely collected data," like the Form 3999 data, to measure city carrier time. In making this assertion, Dr. Neels is apparently unaware of how the Form 3999 data are collected. Unlike the special package and accountable study, in which carriers anonymously recorded their parcel and accountable deliveries, the Form

[5] See, "Report of Kevin Neels on Behalf of United Parcel Service," Docket No. RM2015-7, at 32.

3999 data collection process has the carrier directly observed by his or her manager (or designee). This was explained in the Postal Service's Scoping Study:[6]

> The route evaluation process includes recording the times that the carrier is engaged in the various office and street activities and a mail count conducted by the delivery unit manager or designee. This process includes unannounced selective checks on all of the routes being inspected to verify the accuracy of the mail count. In addition a route examiner makes a physical inspection of the route and then accompanies the carrier for the full tour on the day of the inspection.

Unlike Dr. Neels' claim that it is "unquestionably the case" that carriers know their performance is being measured in the special studies, the reality is that carriers are assured, under union protocols, that the data are collected anonymously and will not be used to evaluate them. Contrast this with the Form 3999 data, which are taken from the route evaluation process that is specifically designed to evaluate the time needed by carriers to complete their routes. This fact would suggest that, if anything, the Form 3999 data are more likely to be subject to the "Hawthorne effect" than the special study data.

Question 1: Should The Regular Delivery Model Be Estimated On Average ZIP Code Values?

Dr. Neels argues that the Postal Service should abandon its use of the 3,400 ZIP Code days of data that it collected in favor of just one average value for each ZIP Code. He thus argues that the regular delivery equation should be estimated on just 294

[6] See, "Scoping Study Report of the United States Postal Service," Docket No. RM2011-3, at 9.

observations.[7] He further argues that this provides a measure of "the longer term effects of volume variation, including its effects on the route restructuring process."[8] Dr. Neels fails to provide a definition of "longer term," and the phase has no established definition. However, he juxtaposes it with the use of the phrase "short term" and emphasizes that it occurs after adjustment processes have taken place. These claims suggest that he is using the term in place of the more familiar economics term of "long-run." Although Dr. Neels fails to provide any reasoning or justification for why the ZIP Code averages provide long-run variabilities, one can assume that he is referring to the historic difference of opinion regarding time-series data (one observation per time period for all units) and cross-sectional data (one observation per unit for one time period). In this discussion, cross-sectional data were presumed to provide long-run cost measures, under the assumption that each cross-sectional unit was operating on its efficient frontier. Being on the efficient frontier is the same as assuming that each cross-sectional unit has completely adjusted all inputs to the level of volume.

Unfortunately for Dr. Neels' analysis, this distinction is not an issue with the Postal Service's estimation exercise. The choice is not between a time series, one observation for all units over an extended period of time, and a cross section, one observation for each unit at a point in time. The Postal Service collected a panel dataset, which in this instance consists of repeated cross-sectional observations over a very short span of time (two weeks). Dr. Neels' suggested "cross-sectional" data set is just the average of those 12 cross-sectional observations. Thus, whatever degree of

[7] See, "Report of Kevin Neels on Behalf of United Parcel Service," Docket No. RM2015-7, at 15.

[8] Id.

input adjustment had taken place in the original data, has also taken place in the averaged data. Averaging the data cannot alter the degree of adjustment of inputs inherent in the data. But, averaging does destroy information useful for estimating the regular delivery equation.

Following the established methodology, the Postal Service estimated the regular delivery equation using a pooled model, in which the variation across ZIP Codes over the 12 days is combined. This provides an effective way to make use of the data collected:[9]

> One of the model variations that witness Bradley tested was a pooled model with a general quadratic functional form for his regression of time on volumes. The pooled model reflects the effects of the cross-sectional and the time dimension of the panel data in a neutral way.

In contrast, Dr. Neels estimated the regular delivery equation on just the ZIP Code average values, and then calculated the variabilities associated with that version of the model.[10] He shows that these calculated variabilities are higher than those found using all ZIP Code days of data, and argues that averaging the collected data transforms the "short-run" variabilities, estimated on the ZIP Code day data, into "long-run" variabilities, which he argues are appropriate to use.

This analysis is undermined by problems of both estimation and interpretation. Furthermore, we see that once these problems are corrected, it becomes clear that estimating the variabilities on the ZIP Code day averages is inappropriate. Review of

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[9] See, Opinion and Recommended Decision, Docket No. R2005-1 at 68.

[10] See, "Report of Kevin Neels on Behalf of United Parcel Service," Docket No. RM2015-7, at 16.

the results of estimating the regular delivery equation on the 294 ZIP Code averages shows that the model is quite poorly estimated. Of the 27 coefficients to be estimated, 15 are statistically insignificant, meaning over half of the estimated coefficients cannot be distinguished from zero.[11] Moreover, many of those insignificant terms are for the first order terms for the volume variables, which are fundamental to the models. The problem is not a situation in which a few higher order terms are insignificant. In fact, in the ZIP Code average model, <u>all</u> the first and second order terms for the volume variables (DPS mail, cased mail, sequenced mail, FSS mail and collection volumes) are insignificant. This result, by itself, demonstrates that using the ZIP Code average data to estimate the regular delivery equation is inappropriate.

Dr. Neels then uses these insignificant coefficients to calculate the variabilities associated with the model. This exercise also demonstrates the inadequacy of using the ZIP Code average values, because doing so produces a negative variability (and marginal time) for sequenced mail, a result which simply cannot be. As Dr. Neels suggests, this is likely a consequence of the fact that so few observations are used to estimate the model.[12]

A check on the robustness of this cross-sectional model is to re-estimate the model with the initial insignificant terms dropped, and then recalculate the variabilities. The results of this routine check are presented in USPS-RM2015-7/3.

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[11] In an attempt to be flexible in evaluating the ZIP Code average model, I applied the relatively relaxed standard of 10 percent level of confidence for identifying statistically significant coefficients. At the more standard 5 percent level, there are only 9 of 27 coefficients which are statistically different from zero. In other words, under standard testing procedures, two-thirds of the estimated coefficients are not significant.

[12] <u>See</u>, "Report of Kevin Neels on Behalf of United Parcel Service," Docket No. RM2015-7, at 15.

Dropping the variables insignificant coefficients leads to a very different set of variabilities, which suggests that the ZIP Code average model is fragile. The variabilities associated with the refined ZIP Code average model are presented in Table 1. When the 15 insignificant terms are removed, the resulting variabilities are lower than those estimated on all of the data, not higher as Dr. Neels' initial results suggested.[13] Note that the sequenced mail variability is zero because all of the terms in sequenced mail were statistically insignificant, a result which suggests sequenced mail requires no time to deliver.

Table 1
Estimated Variabilities from the Pooled and ZIP Code Average Models

	Using All Data	Using ZIP Code Averages But Dropping 15 Variables With Insignificant Coefficients
DPS	16.8%	11.1%
Cased Mail	7.0%	5.3%
Sequenced	3.4%	0.0%
FSS	3.0%	2.7%
Collection	5.4%	4.8%
Sum	**35.6%**	**23.9%**

These results from the refined ZIP Code average model also highlight a problem with Dr. Neels' interpretation of ZIP Code average results. Dr. Neels argues that the

[13] Even dropping the 15 variables with insignificant coefficients does not solve the problem as in this second round estimation there continue to be variables with insignificant coefficients. For purposes of comparison with Dr. Neels' original results, I follow his procedure of using the insignificant coefficients to calculate the variabilities.

"long-run," ZIP Code average variabilities should be higher than short-run variabilities. But such an interpretation relies upon an important implicit assumption that Dr. Neels does not address.

The short run is defined as situation in which at least one input is constrained from adjusting. When one input is constrained, a firm cannot optimally adjust its inputs to a change in volume, and the resulting change in cost is necessarily greater than in the long-run, when all inputs are variable. As a result, one would expect the long-run variabilities to be less than the short-run variabilities. This also makes common sense, as in the long run, the firm can figure out the most efficient method of dealing with the volume change, but in the short run, it may need to apply a more costly, but convenient response.

The exception to this general rule arises when there is excess capacity of an input that is held fixed.[14] Apparently this is what Dr. Neels is assuming, but he did not allege excess capacity existed and never mentioned the possibility that any of the Postal Service's inputs were in excess capacity. If that were the case, then his estimation of the model on the daily ZIP Code averages would be inappropriate, as that estimation did not include any of the constraints associated with excess capacity. Moreover, if Dr. Neels believes that the Postal Service has excess capacity in street time labor, than the variabilities of all volumes, including packages, should be zero, as additional volumes would not require any additional delivery time.

In sum, refining the estimation process for the average ZIP Code data model produces lower variabilities, not higher variabilities as suggested by Dr. Neels. This

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[14] The short run is defined as a situation in which at least one input is held fixed. If all inputs can be adjusted, the long run obtains.

fragility raises serious concerns about this approach. Moreover, if one believes that using the average values does somehow represent a long-run cost, then lower variabilities should be the expected result.

Question 2: Should Packages Be Included In The Regular Delivery Equation?

To ensure that package delivery time was appropriately accounted for, the Postal Service separately investigated the time associated with the delivery of packages, both those that fit in the receptacle, and those that require a deviation. It pursued a study that separately isolated and measured all package delivery time. The result of this effort was to identify a much larger portion of time associated with package delivery than was recorded in the Form 3999 process.

In contrast, Dr. Neels seems to be suggesting that the Postal Service model understates package delivery time, as its relies upon an assumption there is no street time, other than direct package delivery time, associated with packages.[15] This is not correct; portions of street support time, like driving to and from the route and relay time, are in fact associated with packages in the Postal Service model. Contrary to Dr. Neels' assertion, the Postal Service does not assume that this general street time is not associated with packages. Rather, it is assumed that the time associated with directly delivering letters and flats is not caused by those packages that are delivered separately from letters and flats. This is not a new assumption. This was first proposed

[15] See, "Report of Kevin Neels on Behalf of United Parcel Service," Docket No. RM2015-7, at 5.

in Docket No. R2005-1 for deviation packages and accountables, and was accepted by the Commission.[16]

In this discussion, Dr. Neels confuses small packages that are delivered with flats in the course of regular delivery, and in-receptacle packages, which are too large to be delivered along with the rest of the mail but still fit into the customer's receptacle. As explained in the Postal Service' report, the small packages delivered along with cased flats are included in the regular delivery equation. They are included as part of the cased mail variable. It is only those packages which are too large to be delivered with additional mail, whether they cause a deviation or not, that create package delivery time.

The Postal Service specified a regular delivery time equation in order to develop the variabilities for letter and flat mail like DPS, FSS or sequenced mail. It does not use the regular delivery equation to identify the pools of time against which those variabilities are applied. Those pools of time come from the Form 3999 data that Dr. Neels apparently endorses.[17] Thus, it is a "red herring" to question whether or not the regular delivery equation accounts for package time. It does not account for any time; it estimates variabilities for letters and flats. The real issue, then, is whether the exclusion of a package variable from the regular delivery equation affects the estimated variabilities for the letter and flat volumes included in the equation.

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[16] See, Opinion and Recommended Decision, Docket No. R2005-1 at 54.

[17] See, for example, "Report of Kevin Neels on Behalf of United Parcel Service," Docket No. RM2015-7, at 35.

Dr. Neels argues that packages are an important omitted variable in the regular delivery equation.[18] If that is so, then the estimated variabilities for the regular delivery variables could be biased, because the error term in the regular delivery equation could then be correlated with the right-hand-side variables. Note that this potential bias would imply that the variabilities estimated by the Postal Service are too large. Dr. Neels argues that package volumes are positive correlated with regular delivery time (the dependent variable in the regression), and further argues that across ZIP Codes, package volumes will be positively correlated with letter and flat volumes. In this circumstance, the omitted variables bias, if it is material, will cause the estimate coefficients to be overstated.

In most instances, this possibility cannot be checked. But if one accepts Dr. Neels' estimation of the regular delivery equation with packages included (and it is not clear one should), then that model could be used to test whether or not inclusion of packages in the regular delivery equation significantly affects the estimated coefficients. That test would compare the coefficients from the two models using the following test statistic:

$$Z = \frac{\beta_A - \beta_B}{\sqrt{s_A^2 + s_B^2}}$$

In this equation, β_A represents the estimated coefficient from the regular delivery model without packages and β_B represents the estimated coefficient from the regular

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[18] See, "Report of Kevin Neels on Behalf of United Parcel Service," Docket No. RM2015-7, at 11.

delivery model with packages. If the absolute value of the calculated Z statistic is greater than 1.96, then one can reject the hypothesis that the coefficients from the two models are the same. The following table provides the results of the tests for the estimated coefficient in the regular delivery equation.[19] In no instance can the hypothesis of the same coefficients be rejected.

Table 2
Tests of Equality of Coefficients from a Regular Delivery Model With and Without a Package Variable Included

Coefficient	**Original Specification without Packages**	**Neels Specification With Packages**	**Difference**	**Original SE**	**Neels SE**	**Z test**
DPS	5.03E-04	4.26E-04	-7.71E-05	1.24E-04	1.25E-04	-0.44
DPS2	-6.79E-09	-7.13E-09	-3.34E-10	1.27E-09	1.34E-09	-0.18
CM	8.23E-04	5.75E-04	-2.48E-04	3.44E-04	3.57E-04	-0.50
CM2	-2.07E-08	-1.70E-08	3.72E-09	6.65E-09	6.91E-09	0.39
SEQ	9.24E-04	8.37E-04	-8.68E-05	1.05E-04	1.15E-04	-0.56
SEQ2	-2.04E-08	-2.06E-08	-1.56E-10	3.58E-09	3.47E-09	-0.03
FSS	2.33E-03	1.93E-03	-4.00E-04	3.88E-04	3.86E-04	-0.73
CV	1.13E-03	1.24E-03	1.10E-04	5.24E-04	5.20E-04	0.15
CV2	-8.19E-08	-7.90E-08	2.92E-09	2.51E-08	2.48E-08	0.08
DPSCM	1.90E-08	1.54E-08	-3.59E-09	6.24E-09	6.50E-09	-0.40
DPSCV	-6.18E-08	-5.13E-08	1.06E-08	1.26E-08	1.32E-08	0.58
DPSPD	4.28E-08	4.57E-08	2.82E-09	9.90E-09	1.02E-08	0.20
CMCV	1.07E-07	9.17E-08	-1.50E-08	2.67E-08	2.71E-08	-0.40
CMPD	-4.99E-08	-4.51E-08	4.84E-09	2.09E-08	2.18E-08	0.16
FSSCV	1.24E-07	1.18E-07	-6.06E-09	2.87E-08	3.16E-08	-0.14
FSSPD	-1.08E-07	-9.42E-08	1.34E-08	2.12E-08	2.13E-08	0.44
CVPD	1.36E-07	1.43E-07	6.72E-09	3.51E-08	3.55E-08	0.13

These results indicate that there is no omitted variables bias in the regular delivery equation from excluding the DOIS package volumes. They also suggest that the estimated coefficients on the DOIS package variables found by Dr. Neels may be

[19] The program used to implement these test and the computation of the tests statistics are presented in USPS-RM2015-7/3

the result of spurious correlation, perhaps because of the serious measurement errors in the collection of DOIS packages volumes. Note that 5 of the 8 package coefficients are not significantly different from zero.

Note also the Dr. Neels' misstates econometric theory with his claim that he knows the direction of bias arising from measurement error for the included package variable. Dr. Neels refers to the well-known "attenuation" result, for random measurement error for right-hand-side variables.[20] That is, one can show that when the measurement error is random, then the estimated coefficients on the mis-measured variable will be understated. But as Dr. Neels explains in his report, the measurement error for DOIS parcels is systematic, not random. Dr. Neels reported that specific delivery units repeatedly did not report any volume for parcels, so that part of the measurement error is known to be systematic and the direction of bias is unknown. In addition, Dr. Neels does not discuss the fact that the package volume he uses also includes mis-measurement of actual package volumes for some ZIP Codes.[21] These ZIP Codes persistently misreported their package volumes, but it is not known whether they understated or overstated their volumes.

Question 3: Should The Regular Delivery Equation Include Aggregated Volume Measures Or Individual Volume Measures?

Although Dr. Neels does not clearly articulate the point, his report does indirectly raises the legitimate question of whether the regular delivery equation should include many different individual volume variables, or one or two aggregated volume variables.

[20] See, "Report of Kevin Neels on Behalf of United Parcel Service," Docket No. RM2015-7, at 8.

[21] Id.

Dr. Neels' inability to clearly articulate this point apparently comes from his confusion of two different concepts in econometric modeling, complexity and aggregation. Dr. Neels argues that the quadratic functional form is "complex" because it includes many right-hand-side terms.[22] This is incorrect. The quadratic functional form is relatively simple and well known. Unlike his truly complex nonlinear, constant elasticity, specification, the quadratic form has been described in textbooks, its properties are well explored, and it can be estimated with standard econometric methods.[23] In fact, to see its simplicity, consider a quadratic model with just one variable:

$$y = \beta_0 + \beta_0 x + \beta_2 x^2$$

The multiple right-hand-side terms to which Dr. Neels refers arise not from complexity, but from the fact that the regular delivery equation has five individual volume variables. Theoretically, there is no reason not to include separate volume terms in the regression. Some of them may yield similar marginal costs, but there is no cost, theoretically, for allowing for small differences. When using a finite data set, however, the limitations placed on estimation by that data comes into play and aggregation can be considered

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[22] See, "Report of Kevin Neels on Behalf of United Parcel Service," Docket No. RM2015-7, at 2.

[23] In contrast, Dr. Neels' nonlinear model is apparently so complex that he was not able to compute and present the separate variabilities for parcel and non-parcel volumes. He was able to calculate the variabilities for the quadratic model.

In fact, the aggregation issue was first raised and explained for the regular delivery equation by the Postal Service in 2012:[24]

> An important consideration when selecting the volume cost driver(s) is to choose between an aggregated approach and a disaggregated approach. In the aggregated approach, delivery time is related to sum of all volume being delivered, whereas in the disaggregated approach, total volume is subset into volume groupings assumed to have the same cost-causing characteristics. The advantage of an aggregated approach is that it eliminates the multicollinearity problem that occurs in street time regressions and increases the likelihood of estimating precise regression coefficients. The disadvantage of the aggregated approach is that is assumes that all volume subaggregates have the same marginal times.
>
> This suggests that the choice between an aggregated and disaggregated approach relates to the relative precision of the estimates in the two methods and the degree to which there are material differences in the marginal times among the disaggregated volume groups. The greater the gain in precision in estimation from aggregation, the greater the advantage of the aggregated approach, and the greater the true differences in marginal times for the disaggregated volume groupings, the greater the disadvantage of the aggregated approach.

Obviously, one cannot empirically pursue this question, unless one first estimates the model with separate individual volumes included. Such an estimate is necessary for any tests of equality of coefficients or marginal times. Moreover, Dr. Neels' analysis does not address the important fact that the individual mail types used in the Postal Service's regular delivery equation reflect the ways in which city carriers

[24] See, Scoping Study Report of the United States Postal Service, Docket No. RM2011-3, at 47.

actually deliver the mail, so there is a strong operational basis for investigating the possibility of different marginal costs and variabilities. Finally, Dr. Neels does not address the fact that Postal Service first presented this specification for public discussion in 2012, and no objections were raised. Consequently there was a consensus developed that this was a reasonable approach to follow. This was explained by the Commission in early 2013:[25]

> The following areas of consensus emerged from the Second Technical Conference:
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> - Further investigation is needed to determine whether it would be feasible to use DOIS, especially the quality of time data, to estimate econometric models of street time variability;
>
> - A special study of deviation parcel, accountable, and possibly collection times and volumes would be needed to accurately determine time pool percentages and estimate econometric models of volume variability;
>
> - Because bundles of different mail shapes have a significant impact on carrier street time costs, different types of bundle variables should be considered for inclusion in a volume variability model.

To examine the aggregation issue, Dr. Neels tests some, but not all, of the marginal times for individual variables and shows that some pairs of the marginal times are close together.[26] It is not clear why Dr. Neels did not test all pairs of marginal times,

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[25] See, PRC Order N0. 1626, Docket No. RM2011-3, January 18, 2013, at 3.

[26] Unfortunately, Dr. Neels does not provide the formula for his proposed tests of marginal costs so it is impossible to determine their validity. This is relevant because his

as that would be the appropriate approach to investigating aggregation. To complete the analysis, I calculated test statistics for all pairs of the volume variables.

The complete set of tests marginal times provides a different research path than the one put forth by Dr. Neels. To see this, first note that with five different volume types, there are 10 separate pairs to be tested. Dr. Neels only tested (or only reports the results) for 4 of those tests. As the next table shows Dr. Neels reported results only for the 4 tests that do not reject the null hypothesis of equal marginal times. In contrast, all of the other 6 tests reject that hypothesis, demonstrating that it is inappropriate to aggregate all of the individual volumes into just one volume variable, as Dr. Neels proposes.

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proposed test is not a standard test. Review of the STATA software documentation indicates that the procedure he used is appropriate for testing linear combination of coefficients. However, Dr. Neels' proposed test employs linear combinations of the estimated coefficients <u>and</u> the right-hand-side variables. Dr. Neels does not explain how his test incorporates the variances of those right-hand-side variables in the test statistic.

Table 3
Testing the Hypotheses of Equal Marginal Times

1st Volume Type	2nd Volume Type	t-statistic	p-value	Result	Reported By Dr. Neels?
DPS	CM	-1.44	0.149	Do Not Reject	Yes
DPS	SEQ	-1.72	0.086	Do Not Reject	Yes
DPS	FSS	-8.19	0.000	Reject	No
DPS	CV	-7.39	0.000	Reject	No
CM	SEQ	0.38	0.704	Do Not Reject	Yes
CM	FSS	-3.07	0.002	Reject	No
CM	CV	-3.25	0.001	Reject	No
SEQ	FSS	-3.99	0.000	Reject	No
SEQ	CV	-3.70	0.000	Reject	No
FSS	CV	-0.55	0.584	Do Not Reject	Yes

Of course, testing marginal times somewhat misses the key point of model specification. The right specification question to ask is if there are any differences between the <u>estimated coefficients</u> in the regular delivery model. If there are such differences, then using disaggregated volume would be appropriate, even if the resulting marginal times are statistically close to one another. This is because the goal of the regular delivery equation is to estimate the <u>variabilities</u> of the individual volumes, not their marginal costs. If the estimated coefficients are indeed different across volume measures, then those different coefficients should be used in calculating variabilities.

For example, the following table presents the coefficients from the regular delivery equation for DPS, cased, and FSS mail. These pairs permit comparison of coefficients for one pair of volumes for which Dr. Neels' test did not reject the null hypothesis of equality of marginal times and one pair of volumes for which the test did reject that hypothesis.

Table 4
Estimated Coefficients For Selected Variables from Regular Delivery Equation

	DPS	**Cased Mail**	**FSS**
First Order	1.81	2.96	8.38
Second Order	-0.00002	-0.00007	0
Cross with Collection Volume	-0.00022	0.00038	-0.00045
Cross with Possible Deliveries	0.00015	-0.0018	-0.0039

The next table presents standard Chi Square tests for equality of the coefficients using the standard errors adjusted for heteroscedasticity. The table reveals that the tests indicate rejection of the hypotheses that the estimated coefficients are the same in six out seven cases.

Table 5
Tests of Equality of the Estimated Coefficients From the Regular Delivery Equation

	DPS vs CM		DPS vs FSS	
	Test Statistic	**Prob. Value**	**Test Statistic**	**Prob. Value**
First Order	0.6	0.439	15.96	0.0001
Second Order	4.44	0.035	na	na
Cross with Collection Volume	24.29	0.0001	24.77	0.0001
Cross with Possible Deliveries	12.87	0.0003	28.6	0.0001

These tests indicate that that there are significant differences between the coefficients across the different volume variables, calling into question whether aggregation is appropriate.

Notwithstanding these results, if one wants to pursue aggregation, there is a clear path to doing so. That approach is to test the full set of marginal times and chose an aggregation consistent with those tests. If, for example, one cannot reject the null hypotheses of equal marginal times for all volume, then a single aggregate volume variable would be appropriate. At the other extreme, if one rejects all of the null hypotheses, then including all of the individual volume types would be appropriate.

A review of the full set of marginal time tests shows two distinct groups of volume variables. Three of the individual volume variables, DPS mail, cased mail, and sequenced mail have marginal times in the region of 2 to 3 seconds and the statistical tests show that one cannot reject the null hypotheses they have similar marginal times. The other two individual volume variables, FSS and collection mail, have marginal times in the area of 5 to 6 seconds, and the tests show that one cannot reject the null that they have similar marginal times. However, one can reject the null hypotheses that volume types in the first group have similar marginal times to volume types in the second group.

These results contradict the approach of collapsing all volumes into a single aggregate variable, in favor of aggregation into two aggregate volume variables, one for the volumes with relatively low marginal times (DPS, Cased Mail and Sequence) and one for volumes with relatively high marginal time volumes (FSS and Collection Mail). The resulting model specification is given by:

$$
\begin{aligned}
DT_{it} \; = \; & \beta_0 + \beta_1\, VL_{it} + \beta_{11} VL_{it}^2 + \beta_2\, VH_{it} + \beta_{21} VH_{it}^2 + \beta_3\, DP_{it} + \beta_{31} DP_{it}^2 \\
& + \beta_{12}\, VH_{it} * VL_{it} + \beta_{13}\, VH_{it} * PD_{it} + \beta_{23}\, VL_{it} * PD_{it} + \beta_4\, DM_{it} \\
& + \beta_{41} DM_{it}^2 + \beta_5\, MPDP_{it} + \beta_{51} MPDP_{it}^2 + \beta_6\, BR_{it} + \beta_{611} BR_{it}^2 + \varepsilon_{it}
\end{aligned}
$$

Where:

DT = Regular Delivery Time

VL = Sum of DPS, Cased Mail and Sequenced Mail

VH = Sum of FSS and Collection Volume

DP = Delivery Points

DM = Delivery Mode Indicator

MPDP = Miles per Delivery Point

BR = Proportion of Business Deliveries

Initial estimation of this model yielded two insignificant coefficients, the coefficient on the second order term for VH and the coefficient on the cross-product between VL and VH. These two terms were dropped and the model was re-estimated. The results are presented in Table 6.[27]

[27] The results of the full model estimation are provided in USPS-RM2015-7/3. The null hypothesis of equal marginal times between the two volume aggregates is rejected with at t-statistic of 14.8 in the full model.

Table 6

Results of Estimating the Regular Delivery Equation With Two Aggregate Volume Variables

Variable	**Estimated Coefficients**	**H.C. t-statistics**
INTERCEPT	-17.43	-12.99
LV	1.84	6.16
LV2	-0.00001	-4.97
HV	8.39	7.70
PD	26.03	23.45
PD2	-0.00056	-8.35
LV*PD	0.00012	4.39
HV*PD	-0.00021	-2.85
DT	47.93	15.30
DT2	-31.00	-9.43
MPDP	83.85	6.99
MPDP2	-132.84	-6.48
BR	-58.43	-6.00
BR2	75.48	5.29
R2	0.8365	
# of Obs.	3485	

The model with these two aggregate variables yields the following variabilities and marginal times:

Table 7
Variabilities and Marginal Times from Delivery Time Model with Two Aggregate Volume Variables

Aggregate Volume Measure	Variability	Marginal Time
VL	25.4%	2.11
VH	8.9%	5.86

One can test whether the marginal times are significantly different for the two aggregate volume variables.[28] The test result is given in the next table and it provides rejection of the null hypothesis of equal marginal costs, again indicating that estimating a model with just one aggregate volume variable is inappropriate.

Table 8
Test of Equality of Marginal Times

Difference in MC	Standard Error	t-statistic
-3.75	1.59	-2.36

In order to distribute the costs to products, these aggregate variabilities must be broken down to the individual components. This is done by volume weighting the aggregate variabilities. For example, the variability for DPS mail is given by:

[28] The test of equal marginal time is done through a bootstrap procedure. The marginal times and the difference between those marginal times are computed for each of the 3,485 observations used to estimate the equation. This provides a distribution for the difference. That distribution is then used to test the null hypothesis that the difference is zero.

$$\varepsilon_{DPS} = \left(\varepsilon_{DPS}\frac{V_{DPS}}{V_{LMC}}\right)$$

Application of this formula provides the following variabilities, which are shown in Table 9 along with those from the disaggregated model.

Table 9
Variabilities from the Aggregated and
Disaggregated Volume Models

Volume Type	**Disaggregated Model**	**Aggregated Model**
DPS	16.80%	17.29%
Cased Mail	7.00%	5.33%
Sequenced	3.40%	2.77%
FSS	3.00%	3.35%
Collection	5.40%	5.56%
Sum	35.60%	34.30%

There is very little difference between the variabilities for the disaggregated model and the variabilities for the aggregated model. This is strong evidence that there is no problem with the precision of the estimated coefficients (and marginal times) in the disaggregated model. Rather, the results simply show that some types of mail have similar marginal times.

One can also show that using the aggregate variabilities has virtually no impact on attributable costs per piece. The next table presents the unit attributable costs produced by both sets of variabilities. The disaggregated variabilities produced the unit costs labelled “Proposal 13” and the aggregated variabilities produce the costs labeled as “Aggregate Volume Model.”

Table 10

Costs Per RPW Piece from the Proposal 13 Model and the Aggregate Volume Model			
CLASS, SUBCLASS, OR SPECIAL SERVICE	AGGREGATE VOLUME MODEL TOTAL COST PER RPW	PROPOSAL 13 TOTAL COST PER RPW	CHANGE IN TOTAL COST PER RPW
Market Dominant Products			
FIRST-CLASS MAIL			
SINGLE-PIECE LETTERS	$ 0.260	$ 0.259	$ 0.001
SINGLE-PIECE CARDS	$ 0.262	$ 0.262	$ (0.000)
PRESORT LETTERS	$ 0.117	$ 0.116	$ 0.000
PRESORT CARDS	$ 0.079	$ 0.079	$ (0.000)
FLATS	$ 0.873	$ 0.878	$ (0.005)
PARCELS	$ 2.401	$ 2.401	$ 0.000
TOTAL FIRST-CLASS	$ 0.201	$ 0.201	$ 0.000
STANDARD MAIL			
HIGH DENSITY & SATURATION LETTERS	$ 0.061	$ 0.063	$ (0.002)
HIGH DENSITY & SATURATION FLATS & PARCE	$ 0.088	$ 0.096	$ (0.008)
EVERY DOOR DIRECT MAIL - RETAIL	$ 0.050	$ 0.058	$ (0.008)
CARRIER ROUTE	$ 0.193	$ 0.196	$ (0.003)
LETTERS	$ 0.102	$ 0.102	$ 0.000
FLATS	$ 0.456	$ 0.459	$ (0.003)
PARCELS	$ 1.586	$ 1.586	$ 0.000
TOTAL STANDARD MAIL	$ 0.136	$ 0.138	$ (0.002)
PERIODICALS			
IN COUNTY	$ 0.147	$ 0.150	$ (0.003)
OUTSIDE COUNTY	$ 0.366	$ 0.369	$ (0.003)
TOTAL PERIODICALS	$ 0.345	$ 0.349	$ (0.003)
PACKAGE SERVICES			
SINGLE-PIECE PARCEL POST	$ 11.541	$ 11.541	$ 0.000
BOUND PRINTED MATTER FLATS	$ 0.562	$ 0.566	$ (0.004)
BOUND PRINTED MATTER PARCELS	$ 1.238	$ 1.238	$ 0.000
MEDIA AND LIBRARY MAIL	$ 3.967	$ 3.967	$ (0.000)
TOTAL PACKAGE SERVICES	$ 1.969	$ 1.971	$ (0.002)
Total Domestic Market Dominant Mail	$ 0.180	$ 0.182	$ (0.001)
Ancillary Services			
CERTIFIED	$ 2.149	$ 2.149	$ -
COD	$ 7.348	$ 7.348	$ -
INSURANCE	$ 2.612	$ 2.612	$ -
REGISTRY	$ 12.395	$ 12.395	$ -
Total Domestic Competitive Costs	$ 2.924	$ 2.924	$ (0.000)

Question 4: Should a Regular Delivery Time or a Total Street Time Equation be Estimated?

Dr. Neels expresses concern about what he calls the “fragmentation” of the attributable costing analysis of city carrier street time.[29] But, this voiced concern appears to reveal a misunderstanding of the nature of the city carrier cost model. My review of the city carrier street time cost pools shows them to be relatively concentrated, not fragmented. There appear to be far fewer cost pools in city carrier street time than in other major cost segments like mail processing or purchased highway transportation.

My review suggests that there are only four cost pools in the city carrier street time model for which variabilities need to be estimated. They are regular delivery time, parcel and accountable delivery time, collection from street letter box time, and network travel time. These four cost pools account for 84 percent of city carrier street time and the remaining 16 percent of time uses the variabilities estimated for these four cost pools. This breakout is presented in the following table. The time associated with the indirect cost pools, travel to and from the route, relay time, and other indirect time, are attributed based upon the overall variability in the for direct cost pools. In other words, the sizes of each of the other four direct cost pools are increased, to account for their portion of indirect time.

[29] See, “Report of Kevin Neels on Behalf of United Parcel Service,” Docket No. RM2015-7, at 4.
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Table 11
Breakout of City Carrier Street Time into Cost Pools

Regular Delivery	72.05%	83.95%
PA Delivery	9.02%	
Collection from SLB	0.18%	
Network Travel	2.70%	
Travel To From	4.63%	16.05%
Relay	3.52%	
Other Indirect Time	7.90%	

This means that once the indirect time is assigned back to the main cost pools, the breakout of city carrier street time cost pools is given as follows:

Table 12

Breakout of City Carrier Street Time into Cost Pools
Incorporating Indirect Time

Regular Delivery	85.83%
PA Delivery	10.74%
Collection from SLB	0.22%
Network Travel	3.21%

In Proposal 13, the Postal Service provides new variabilities for both regular delivery and parcel and accountable delivery, which together account for 96.6 percent of carrier street time. Thus, the "fragmentation" that Dr. Neels is apparently concerned about relates to just 3.4 percent of street time.

This cost pool breakout clarifies that the true issue associated with estimating a street time equation is not "fragmentation," but rather the estimation of the appropriate variabilities. One approach to that estimation is to use operational data to determine the sizes of the relative cost pools, and then to estimate the individual variabilities for the resulting cost pools. This approach necessarily involves estimating a regular delivery time equation (along with parcel and accountable delivery time equations) and is used both by the Postal Service in Proposal 13 and in the established methodology.

The alternative approach, proposed by Dr. Neels, is to ignore the street time proportions and analyze all street time as a single lump.[30] In this approach, a single street time equation is estimated and the attributable cost pools are then found by multiplying the variabilities from that equation against the single total street time cost pool. This means that to accurately estimate the total street time equation, one needs to have all of the cost drivers of street time. This includes letter and flat volumes, in-receptacle packages, deviation packages, accountables, mail collected from customers and mail collected from street letter boxes. Dr. Neels proposed street time equation fails this specification test because it omits in-receptacle packages, accountables and mail collected form street letter boxes. Consequently, attributable costs cannot be developed for these shapes.

Despite these infirmities, Dr. Neels estimated a street time regression and argues that the results show that the variabilities from the street time regressions are higher than those from regular delivery equation.[31] However, this conclusion arises only because Dr. Neels apparently did not realize that he was comparing apples to

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[30] See, "Report of Kevin Neels on Behalf of United Parcel Service," Docket No. RM2015-7, at 11.

[31] See, "Report of Kevin Neels on Behalf of United Parcel Service," Docket No. RM2015-7, at 13.
.

oranges. The regular delivery equation he analyzes includes variabilities for just letter and flat volumes, but the total street time equation he analyzes includes all those variabilities plus a variability for packages. Not surprisingly, when the package variability is added to the mix, the sum of the variabilities increases. As the next table shows, when one does an apples-to-apples comparison, there is virtually no difference between the sum of the regular delivery time variabilities and the sum of the street time variabilities.

Table 13
Comparing Regular Delivery Time Variabilities With Street Time Variabilities

	Regular Delivery Equation	Neels Street Time Equation
DPS	16.8%	17.4%
Cased Mail	7.0%	7.8%
Sequenced	3.4%	3.3%
FSS	3.0%	1.9%
Collection	5.4%	5.4%
Sum of Letter and Flat Variabilities	**35.6%**	**35.8%**
Packages		4.9%

This result indicates that the only difference between the two approaches is that in one approach, the package (and accountable) variabilities are estimated in a separate equation, and in the other approach they are estimated as part of the street time equation.

It is impossible to completely institute Dr. Neels' approach to using a street time variability because it does not explicitly provide variabilities for in-receptacle packages, accountables or mail collected from street letter boxes. Nevertheless, one can investigate whether his proposed approach would provide materially different attributable costs per piece by approximating its implementation.

To do so, one can take his estimated variabilities (by assuming that accountables are part of his package variable) and apply them to the total street time cost pools. The next table compares the attributable costs per piece for Proposal 13 with an experiment of applying the variabilities from Dr. Neels' street time equation. A comparison of those results shows no material differences in unit costs. Given this result, and given the hurdles involved in accurately estimating a street time equation, it is a reasonable conclusion that there is no reason to further pursue this approach.

Table 14

Costs Per RPW Piece from the Proposal 13 Model and A Street Time Model

CLASS, SUBCLASS, OR SPECIAL SERVICE	STREET TIME MODEL TOTAL COST PER RPW	PROPOSAL 13 TOTAL COST PER RPW	CHANGE IN TOTAL COST PER RPW
Market Dominant Products			
FIRST-CLASS MAIL			
SINGLE-PIECE LETTERS	$ 0.267	$ 0.259	$ 0.008
SINGLE-PIECE CARDS	$ 0.271	$ 0.262	$ 0.009
PRESORT LETTERS	$ 0.121	$ 0.116	$ 0.005
PRESORT CARDS	$ 0.083	$ 0.079	$ 0.004
FLATS	$ 0.888	$ 0.878	$ 0.010
PARCELS	$ 2.448	$ 2.401	$ 0.047
TOTAL FIRST-CLASS	$ 0.207	$ 0.201	$ 0.006
STANDARD MAIL			
HIGH DENSITY & SATURATION LETTERS	$ 0.069	$ 0.063	$ 0.006
HIGH DENSITY & SATURATION FLATS & PARCE	$ 0.102	$ 0.096	$ 0.007
EVERY DOOR DIRECT MAIL - RETAIL	$ 0.065	$ 0.058	$ 0.007
CARRIER ROUTE	$ 0.198	$ 0.196	$ 0.002
LETTERS	$ 0.107	$ 0.102	$ 0.005
FLATS	$ 0.462	$ 0.459	$ 0.003
PARCELS	$ 1.641	$ 1.586	$ 0.055
TOTAL STANDARD MAIL	$ 0.143	$ 0.138	$ 0.005
PERIODICALS			
IN COUNTY	$ 0.153	$ 0.150	$ 0.003
OUTSIDE COUNTY	$ 0.372	$ 0.369	$ 0.003
TOTAL PERIODICALS	$ 0.351	$ 0.349	$ 0.003
PACKAGE SERVICES			
SINGLE-PIECE PARCEL POST	$ 11.553	$ 11.541	$ 0.012
BOUND PRINTED MATTER FLATS	$ 0.572	$ 0.566	$ 0.006
BOUND PRINTED MATTER PARCELS	$ 1.265	$ 1.238	$ 0.027
MEDIA AND LIBRARY MAIL	$ 3.995	$ 3.967	$ 0.028
TOTAL PACKAGE SERVICES	$ 1.988	$ 1.971	$ 0.018
Total Domestic Market Dominant Mail	$ 0.187	$ 0.182	$ 0.005
Ancillary Services			
CERTIFIED	$ 2.149	$ 2.149	$ -
COD	$ 7.348	$ 7.348	$ -
INSURANCE	$ 2.612	$ 2.612	$ -
REGISTRY	$ 12.395	$ 12.395	$ -
Total Domestic Competitive Costs	$ 2.955	$ 2.924	$ 0.030

Question 5: Is Dr. Neels' Constant Elasticity Model Acceptable?

Dr. Neels presents an *ad hoc,* non-linear, constant elasticity model of street time which incorporates a single term for all volume raised to a constant elasticity, along with terms for delivery points and miles per delivery point, also raised to their own constant elasticity. The delivery mode variable enters linearly.[32] The volume term includes a variable for all letters and flats termed the "non-parcel volume" and a single package volume variable, he termed "parcel volume."[33] This functional form appears to have no antecedent in the cost function literature and Dr. Neels does not provide any theoretical background or justification for the form applied in the model.

Because he is using a specific functional form, Dr. Neels is imposing *a priori* restrictions on the cost generating process for city carrier street time, but he provides neither operational nor economic justification for those restrictions. For example, he provides no explanation or justification for why he assumes that the elasticities of street time with respect to total volume or the number of delivery points are constant across all variations in volume levels or delivery points. Typically in a network industry, these elasticities vary as volume or the size of the network changes. Dr. Neels' specification does not allow for this possibility. Also, Dr. Neels does not explain why there is no elasticity provided for the effect of delivery mode on street time, or why just a linear term is included.

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[32] See, "Report of Kevin Neels on Behalf of United Parcel Service," Docket No. RM2015-7, at19.

[33] The fact that Dr. Neels lumps 95 percent of delivered volume into one variable and calls is "non-parcel" volume is potentially revealing. It suggests that Dr. Neels' focus may have been more on parcel costs than trying to specify and estimate the best overall delivery time equation.

Moreover, Dr. Neels' constant elasticity model suffers from a serious specification error. As discussed earlier, the marginal time tests proposed by Dr. Neels unambiguously show that it is inappropriate to combine all letter and flat volumes into a single aggregate variable; but that is the approach that Dr. Neels follows in the constant-elasticity model.

More generally, the specification of the single volume term is unusual. Dr. Neels' earlier work estimating regular delivery and street time models included a parcel volume term, and his results showed that the parcel term had a different variability than the letter and flat volumes. That being the case, the natural way to estimate a constant elasticity model would be to have one or more "non-parcel" volume terms and one parcel volume term, each with its own elasticity, yielding a model specification such as: $NPV^{\gamma_3}\ PV^{\gamma_4}$. But Dr. Neels combines the non-parcel and parcel volumes into one term and then attaches an interior coefficient on parcel volume. Dr. Neels' term thus looks like: $(NPV + \beta PV)^{\gamma_3}$.[34] This means that Dr. Neels is restricting the model, by assuming that $\gamma_3 = \gamma_4$, but provides no investigation of this restriction. Yet such an investigation is straightforward. One need only estimate a standard specification with separate non-parcel volume and parcel volume coefficients, and see if the estimated coefficients are similar. To do this, I estimated a model of the following form:

$$ST = \alpha\, DP^{\gamma_1} \left(\frac{SM}{DP}\right)^{\gamma_2} NPV^{\gamma_3}\ PV^{\gamma_4}\,(1 + \delta DM) + \varepsilon$$

[34] The unusual nature of this specification is highlighted by considering how one would specify it with two, rather than one, "non-parcel" volumes. Would one of the two volumes get its own coefficient? Would both be included with parcel volumes? Because there is no economic or operational basis for this specification, there are no acceptable answers to these questions.

Note that this is just Dr. Neels' model with the restriction of a common exponent on NPV and PV relaxed. Estimation of this model yields the following results:[35]

Table 15
Volume Elasticities from An Unrestricted Constant Elasticity Model

Variable	Coefficient	Standard Error	t-value
Non-Parcel Volume	0.522	0.035	15.04
Parcel Volume	0.037	0.015	2.52

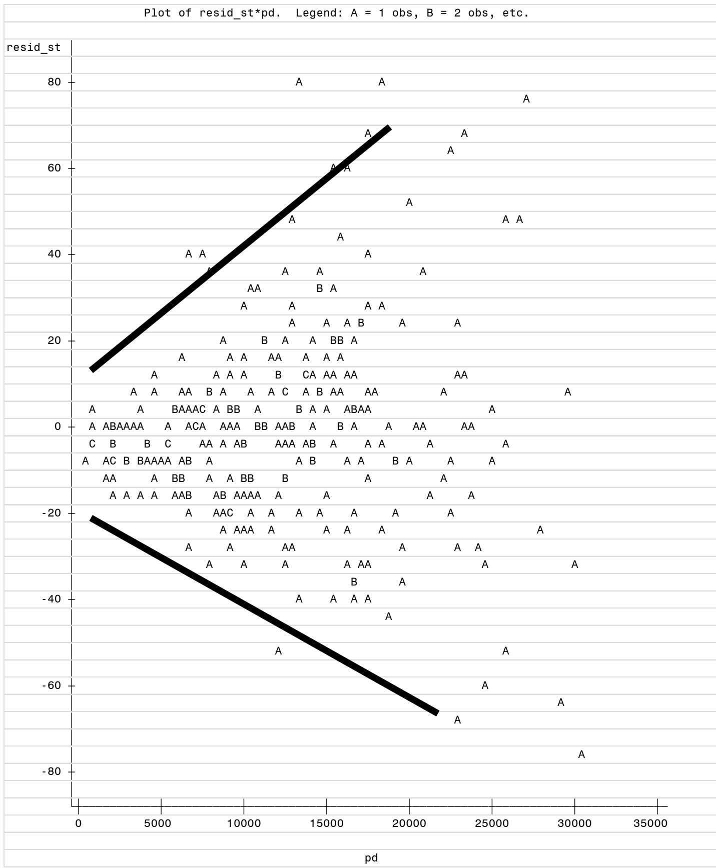
Clearly, the non-parcel volume term and the parcel volume term do not have the same elasticities, meaning Dr. Neels' model is mis-specified.

Dr. Neels' econometric procedure suffers from other disqualifying flaws. First, perhaps because of its nonlinear nature, Dr. Neels did not perform basic econometric checks on the model. He did not check or correct for heteroscedasticity, multicollinearity, or potentially influential observations, all of which could affect the inferences he draws from the model. To demonstrate that this not just a theoretical, but an actual concern, I investigated Dr. Neels' model for the presence of heteroscedasticity.

An initial method for checking for heteroscedasticity is "ocular inspection," examining the residuals to see if they exhibit pattern consistent with constant variance. Below is a plot of the residuals from Dr. Neels' model. That plot shows the variance of

[35] The program used to estimate this model along with full results are presented in USPS-RM2015-7/3

the residuals rising with size of the ZIP Code (as measured by the number of possible deliveries). Thus, the variance is non constant and the model suffers from heteroscedasticity.



More formally, one can test for heteroscedasticity with either the White test or the Breusch-Pagan test. The White test investigates a general specification of the null hypothesis of constant variance:

$$H_o\colon\ \sigma_i^2\ -\ \sigma^2\ \forall\ i.$$

The Breusch-Pagan test investigates the existence of a relationship between the error term and a vector of right-hand-side variables from the regression (z_i):

$$H_o\!: \alpha = 0 \ \ in \ \ \sigma_i^2 \ - \ \sigma^2(\alpha_o + \alpha' z_i)$$

I performed both tests and they both strongly reject the null hypothesis of homoscedastic errors in favor of the presence of heteroscedasticity.

Table 16

Tests of the Null Hypothesis of Homoscedasticity

Test	**Test Statistic**	**Degrees of Freedom**	**Probability Value**
White's Test	104.7	27	<.0001
Breusch-Pagan Test	49.35	2	<.0001

Another problem with Dr. Neels' model is that it is estimated on just 294 observations. Because nonlinear estimation must iterate around a nonlinear surface to estimate the parameters, a shortage of data can be even more critical than in a linear regression. Thus, the nonlinear model should be estimated on the over 3,000 ZIP Code day observations.

In sum, there are many serious problems associated with Dr. Neels' estimated econometric model that render it unusable. The combination of these infirmities also likely renders the resulting variabilities fragile and unreliable. Their unreliability can be demonstrated by correcting three of the infirmities of the model: (1) including separate aggregate variables for low marginal time and high marginal time letter and flat volumes, (2) removing the restriction of a single elasticity parameter, and (3) estimating the model on all ZIP Code day observations. These corrections provide a very different set of variabilities, as shown in the following table. The econometric model that was estimated is given by:

$$ST = \alpha\, DP^{\gamma_1} \left(\frac{SM}{DP}\right)^{\gamma_2} NPV_{LT}^{\gamma_3}\ NPV_{HT}^{\gamma_4}\, PV^{\gamma_5} \left(1 + \delta DM\right) + \varepsilon$$

The resulting variabilities are presented in the following table:[36]

Table 17
Variabilities from the Improved
Constant Elasticity Model

Volume Variables	**Variabilities**
Relatively Low Time Volumes	29.2%
Relatively High Time Volumes	5.3%
Packages	5.5%

Note that sum of the variabilities on the non-parcel volumes is 34.5 percent which is quite close to the 35.6 percent found by the Postal Service in its disaggregated quadratic delivery time model.

[36] The program used to estimate this model along the with full results are presented in USPS-RM2015-7/3